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STRATEGIC DETERMINANTS OF THE ORGANIZATIONAL READINESS FOR SUSTAINABLE DEVELOPMENT IN POLISH PHOTOVOLTAIC COMPANIES

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ABSTRACT: The aim of this article is to present the results of a study on the organisational readiness of photovoltaic (PV) companies in Poland to implement sustainable development principles. A triangulation of research methods was employed in the study. The quantitative component, conducted on a sample of 50 photovoltaic companies, was supplemented by a qualitative investigation aimed at identifying the factors influencing the current state and development potential of sustainability practices within each firm. The findings provided empirical answers to the research questions and confirmed the formulated hypotheses. Moreover, the results addressed an existing research gap concerning the lack of integrated theoretical frameworks of organisational readiness in the photovoltaic sector—frameworks that incorporate technological, operational, financial, and institutional dimensions in the context of renewable energy development. Secondly, the study established a link between organisational readiness and firm performance. The empirical analysis examined how varying levels of readiness affect the financial outcomes, innovation capacity, and competitive positioning of PV companies. Thirdly, the study developed a measurement metric for organisational readiness, enabling the assessment of the extent to which an enterprise is prepared to implement sustainability-oriented strategies in the photovoltaic industry.

KEYWORDS: photovoltaic company, organisational readiness, sustainable development, environment

Introduction

Organisational readiness for sustainable development in photovoltaic enterprises plays a pivotal role in the context of a dynamically evolving market and regulatory environment. In light of global climate challenges and increasing stakeholder expectations, an organisation's ability to implement environmentally and socially responsible strategies is determined by a combination of internal and external factors (Atstaja, 2025; Igliński et al., 2022; Marti et al., 2022). The primary advantages of solar energy generation encompass geographical availability, investment feasibility, low noise emissions, and the predictability of energy output in comparison to other renewable energy sources (RES).

Furthermore, electricity generation from photovoltaic systems is temporally aligned with peak national energy demand, occurring predominantly during daylight hours, which enhances grid stability and energy supply efficiency (Mokarram et al. 2020; Li et al., 2023; Kurowska et al., 2022; Agugliaro et al., 2022). However, societal resistance to such transitions is often pronounced in the early stages of implementation (Miller et al., 2018; Shivakumar et al., 2019; Rissman et al., 2020; Olczak, 2022; Gulkowski, 2022).

An inadequate level of organisational readiness leads to difficulties in implementing sustainable development policies, potentially resulting in a loss of competitiveness, increased operational costs, and limited scalability of business operations (Höckner et al., 2020; Front-Dąbrowska & Kwartalnik-Pruc,2024). Firstly, access to investment capital – PV enterprises require substantial capital expenditures for infrastructure development, research and development (R&D), and the implementation of new technologies (Lados et al., 2020). Secondly, financial stability – liquidity and creditworthiness determine the firm's ability to execute long-term sustainable development strategies (Witkowska-Dąbrowska et al, 2023). Thirdly, financial risk management – fluctuations in raw material prices, energy costs, and subsidy policies can lead to investment uncertainty (Jajuga, 2018; Paska et al., 2020). Fourthly, the ability to secure external financing – the availability of EU funds, green bonds, and support mechanisms (e.g., auction-based support systems) influences the pace of ESG strategy implementation (Wicki et al., 2022). A lack of sufficient financial readiness results in a situation where an enterprise may possess well-developed organisational capabilities.

An overview of the literature

Conditions for the development of the photovoltaic companies

Solar irradiance estimates are generally more accessible and reliable than those for wind energy potential, allowing for more precise forecasting of energy production. Some countries have also revised their national energy policies, incorporating not only ambitious climate targets but also emphasising energy security. In Poland, the assumptions for the update of the current energy policy until 2040 were adopted on March 29, 2022 (Gov_PL, 2021; Olczak, 2021; Pyk, 2023). Analysing the draft versions of the first update of the National Energy and Climate Plans (NECPs), it is evident that several countries have set highly ambitious emission reduction targets (from 1990 to 2030), aiming for reductions of 55% or more by 2030.

Data indicate (Figure 1) that the global energy sector is responding to evolving economic and political conditions, as well as the increasing significance of renewable energy sources in the context of the global energy transition (Rissman, 2020; Hockner, 2020; Shivakumar, 2019). After 2025, a gradual decline in coal-based energy production is projected, along with the stabilisation of natural gas-based energy generation at a lower level (Newbery, 2018; Babatunde et al., 2018; Mamun, 2022). The growth of renewable energy reflects the global commitment to decarbonising the energy sector and reducing greenhouse gas emissions in line with international climate objectives (Miller et al., 2018; Fremstad et al., 2018; Bataille et al., 2018; Ruijven et al., 2019). In Poland, the photovoltaic energy potential is relatively lower than in regions closer to the equator, but still represents a significant source of renewable energy (Sarniak et al., 2020; Dobrzycki et al., 2021; Yang et al., 2019; Muller-Frączek, 2019).

DOI: 10.34659/eis.2026.97.2.1139

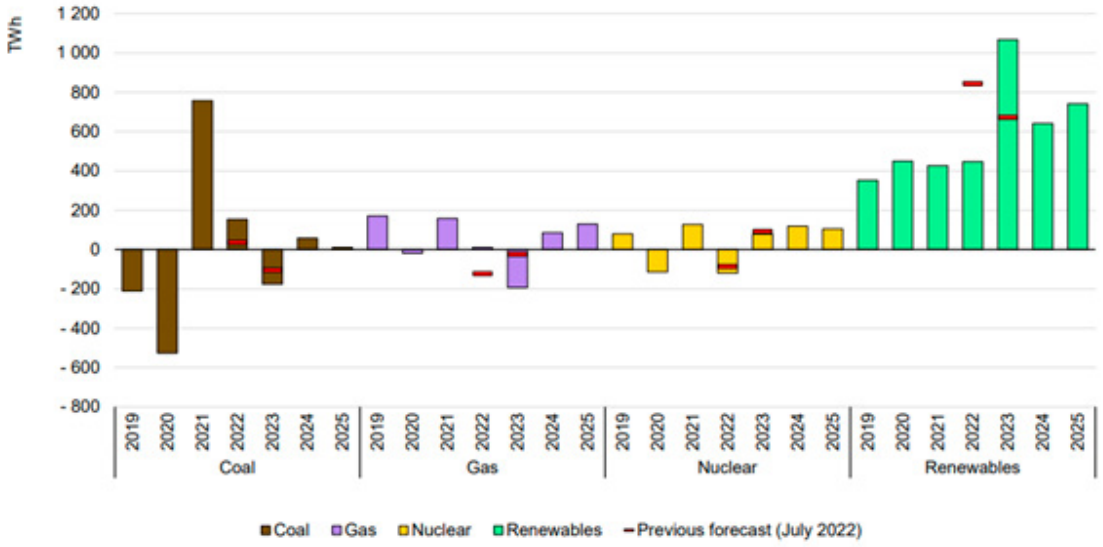

Figure 1. Global Changes in Electricity Generation Sources 2019-2025

Source: International Energy Agency, Electricity Market Report 2023 [https://www.iea.org/reports/electricity-market-report-2023 [21-02-2025].

Factors Driving Photovoltaic Development

Photovoltaic systems constitute a zero-emission energy generation technology, meaning they do not release harmful compounds, carbon dioxide (CO_2), or greenhouse gases during operation. As a result, photovoltaics exhibit one of the lowest environmental footprints among energy production sources (Sala, 2018; Jaworski et al., 2023; Kurowska et al., 2022). Furthermore, electricity generation from photovoltaic systems is temporally aligned with peak national energy demand, occurring predominantly during daylight hours, which enhances grid stability and energy supply efficiency (Wicki et al. 2022; Ciuła et al., 2023; Semeraro et al., 2022). Understanding the dynamics that drive this sector requires a detailed analysis of the key elements presented in Table 1.

Table 1. Factors Driving Photovoltaic Development

Factor	Scope of factor	Analysed factor
Economical	The decreasing costs of photovoltaic installations, driven by technological advancements and economies of scale, play a crucial role in accelerating the adoption of solar energy;	The significant reduction in solar panel prices, coupled with the availability of various financial instruments such as preferential green loans, operational leasing, and Power Purchase Agreements (PPAs), enhances the economic feasibility of photovoltaic projects.
Social	Increasing Environmental Awareness and Changing Consumer Attitudes Toward Renewable Energy	Educational Campaigns and Societal Trends. Increasing awareness of renewable energy benefits, growing investments in photovoltaic systems across different generations, and rising demand for clean energy sources.
Technological	Innovations in Solar Panel Production and Energy Storage Systems	Implementation of smart grid systems, development of more efficient PV panels, advancements in energy storage, and new battery technologies improving energy retention and grid stability.
Legal	Legal Regulations Affecting the Development and Operation of Photovoltaic Systems	The Renewable Energy Sources Act (RES Act), Energy Law, EU directives, and regulations concerning energy balancing and grid connection for photovoltaic installations.
Environmental	Climate Change and Global Commitments to CO_2 Emission Reduction	Increasing number of sunny days, higher photovoltaic potential in regions with strong solar radiation, and air pollution enhancing PV efficiency by diffusing sunlight.

Source: author's work based on qualitative research.

DOI: 10.34659/eis.2026.97.2.1139

The first scope of analysis of the factor is Increasing Environmental Awareness and Changing Consumer Attitudes Toward Renewable Energy (Ruijven et al., 2019; Front-Dąbrowska & Kwartalnik-Pruc, 2020; Tomaszewski & Sekściński, 2020; Guaita-Pradas et al., 2019). The second scope factor is Innovations in Solar Panel Production and Energy Storage Systems. Technological advancements in photovoltaic module manufacturing and energy storage systems contribute to improving the efficiency, durability, and affordability of solar energy solutions (Rissman et al., 2020; Lados et al., 2020; Yang et al., 2019; Herudziński, 2021; Świdyńska, 2024). The third scope of factor is Legal Regulations Affecting the Development and Operation of Photovoltaic Systems. The legislative framework at both national and international levels plays a crucial role in shaping the photovoltaic market (Witkowska-Dąbrowska et al., 2023; Świdyńska, 2024; Seroka, 2022; Przygodzka et al., 2023).

To discuss the legal aspects related to photovoltaic (PV) installations in Poland, it is essential to reference key regulations and legal acts that directly impact the development, installation, and operation of these systems. The Directive (EU) 2018/2001 of the European Parliament and the Council of December 11, 2018, on the promotion of renewable energy use is a fundamental document shaping legal frameworks in Poland. At present, the profitability of PV investments remains largely contingent upon governmental policies and regulatory frameworks.

Organisational readiness for photovoltaic development

Organisational readiness encompasses the interrelationship between human resources, operational processes, technological systems, and performance measurement frameworks. It necessitates synchronisation and coordination, as successful implementation is unattainable in their absence (Wang et al. 2007; Verhoef et al., 2021; Bąkowski et al., 2024). Organisational readiness extends beyond structural preparedness to include the cultural and psychological adaptability of both employees and management (McGuire & Hutchins, 2006; Thundiyil, 2017). Identified variability as the primary dimension of organisational readiness, referring to the extent to which individual characteristics evolve throughout the change process (Weiner, 2009; Arif et al., 2017; Inuwa, 2020).

From the perspective of the Resource-Based View (RBV), organisational readiness for sustainable development can be considered as a set of unique resources and dynamic capabilities that enable photovoltaic (PV) enterprises to effectively implement Environmental, Social, and Governance (ESG) strategies (McGuire & Hutchins, 2006; Lehman et al., 2002; Uluskan et al., 2018; Thundiyil et al., 2017; Arif et al., 2017; Inuwa et al., 2020; Clark et al., 2024; Czupińska & Chodorowska, 2023). First, there is a need for integrated theoretical frameworks that encompass technological, operational, financial, and institutional aspects of organisational readiness in the context of renewable energy sources. Second, the relationship between organisational readiness and firm performance remains largely unexplored. There is a lack of empirical studies analysing the impact of varying levels of organisational readiness on the financial performance, innovation capacity, and competitiveness of PV enterprises. Third, it is essential to develop measurement metrics for organisational readiness that would allow for an objective assessment of the extent to which an organisation is prepared to implement sustainable development strategies.

Research methods Factors

In the chapter, the author should indicate and describe the research methods applied to solve the research problem. The research begins with a literature review and the establishment of theoretical foundations, leading to the formulation of hypotheses and their verification based on collected data. Particularly in the context of entrepreneurship and social sciences, triangulation enables the analysis of data in both quantitative (numerical) and qualitative (descriptive) ways, enhancing the reliability and credibility of research findings (Campbell, 2000). Patton (1985) emphasises that the strength of this method lies not in forecasting outcomes, but in capturing the specificity, contextual richness, and interactive dynamics of a given phenomenon. Similarly, Yin (2009) advocates for the use of case studies when a deeper understanding of a process, structure, or strategic behaviour is required, particularly in situations where the boundaries between the phenomenon and its environment are not clearly defined. In this study, two techniques were applied: Computer-Assisted Web Interviewing (CAWI) and in-depth interviews.

DOI: 10.34659/eis.2026.97.2.1139

The survey questionnaire was distributed via email to members of the management teams of photovoltaic enterprises. The questionnaire was structured into several sections: an introductory statement outlining the purpose and scope of the study, a main body comprising 50 questions – including both closed-ended and open-ended formats and a concluding section focused on respondent demographics.

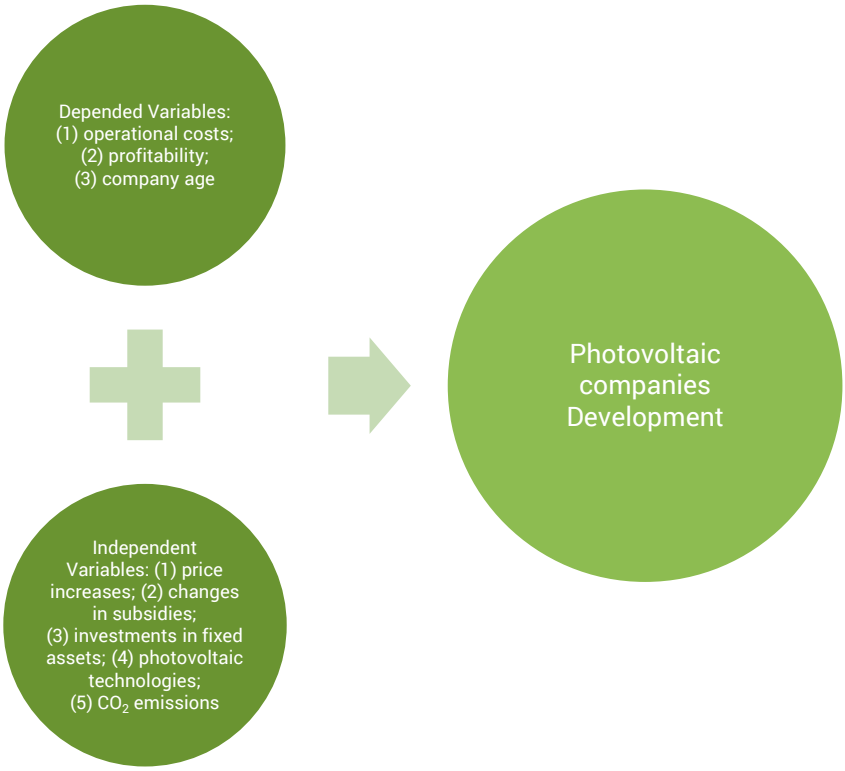

Figure 2. Dependent and Independent Variables in the Research Model

Independent variables are external factors that influence the financial performance of companies (Figure 2). The research method applied in this study is quantitative financial analysis, aimed at examining the profitability of investments in photovoltaic installations in Poland during the years 2019–2021. This method deployed financial indicators such as Net Present Value (NPV), Internal Rate of Return (IRR), and Simple Rate of Return (SRR). NPV enables the assessment of investment profitability by estimating the value of future cash flows. IRR determines the internal rate of return, which indicates the rate of return that yields a positive investment value, while SRR measures return without considering the time value of money, providing insights into short-term profitability.

Furthermore, the first hypothesis assumes that the reduction in financial support in the form of subsidies, such as the "My Electricity" program, did not have a significant impact on the financial performance of companies, indicating their ability to adapt to changing market conditions. The second hypothesis suggests that the increase in electricity prices between 2019 and 2021 significantly improved the financial performance of the examined enterprises, enabling them to generate higher profits and increase their operating margins. The third hypothesis posits that companies that increased their investments in fixed assets and technological development were able to achieve higher profitability, which constituted a competitive advantage during the analysed period. The fourth hypothesis assumes that despite rising operating costs, resulting from higher raw material prices and CO_2 emission costs, photovoltaic enterprises managed to maintain positive financial results through cost optimisation. The fifth hypothesis is based on the assumption that companies with comparable balance sheet totals achieved similar profitability, indicating that external factors, such as subsidies and energy prices, affected them in a comparable manner, regardless of internal differences in management practices. The research sample consists of five selected enterprises operating in the Polish photovoltaic market, which had similar balance sheet totals during the analysed period (2019–2021): House Solutions, Atum Energy, Solar Bruk Bet, Selfa photovoltaics and Sunsol.

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These companies were selected based on their scale of operations, business scope, and focus on the photovoltaic industry, which allows for a more precise analysis of investment profitability in renewable energy sources.

House Solutions is a company specialising in the design, installation, and maintenance of photovoltaic systems. The company operates nationwide in Poland, focusing primarily on the residential sector and small businesses. Atum Energy also engages in the installation and maintenance of photovoltaic systems, but places greater emphasis on serving medium and large enterprises as well as photovoltaic farms. Sunsol is a company that has been specialising for many years in providing comprehensive photovoltaic solutions for both individual customers and large commercial projects.

Results of the research

Overall trends in the sector suggest that photovoltaics in Poland remains a resilient and promising industry, supporting the recommendation for further investment in this area. The declining costs of technology and continued market growth confirm the achievement of Specific Objective 4, which concerns the assessment of the future investment potential in renewable energy sources (RES). A comparison of the five analysed companies reveals significant differences in their scale of operations and ability to generate profits, fulfilling Specific Objective 1. House Solutions stands out as the largest company with the highest revenues and net profits in 2019–2021, supporting both the main hypothesis and Hypothesis 2. Atum Energy has shown stable growth, suggesting that the company effectively capitalised on the increasing demand for photovoltaic installations, which also aligns with the main hypothesis. Sunsol, despite initial difficulties, demonstrated a recovery in 2021, confirming the validity of Hypothesis 4, which assumed that, despite challenging market conditions, companies maintained positive financial results.

Table 3. Summary of Obtained Investment Profitability Indicator Values

Indicator	Atum Energy	Sunsol	House Solutions	Solar Bruk Bet	Selfa photovoltaics
NPV (PLN)	1 389 376	1 180 217	1 859 705	2 174 876	1 745 367
IRR (%)	41	36	1517	1230	1148
SRR (%)	262	176	1889	1976	1567

Source: author's work based on quantitative research.

The results indicate that all companies achieved high profitability indicators, confirming the main hypothesis that photovoltaic investments remained profitable. The highest profitability was recorded by Solar Bruk Bet (Table 3). The Net Present Value (NPV) for Solar Bruk Bet amounted to 2,1 mln PLN, demonstrating that the investment generated substantial net present value, indicating high profitability and the financial viability of the investments made during the analysed period. The Internal Rate of Return (IRR) for Solar Bruk Bet reached 1230%, and the Simple Rate of Return (SRR) was 1976%, signifying an exceptionally high return on investment. Solar Bruk Bet achieved the highest NPV and IRR values, suggesting that its operational and investment strategy was the most effective, thereby supporting Hypothesis 3. Sunsol, despite experiencing difficulties in 2019–2020, managed to recover in 2021, confirming Hypothesis 4, which assumed that companies, despite rising operating costs, were able to maintain positive financial results through cost optimisation. The exceptionally high IRR for House Solutions may be attributed to relatively low initial investment costs compared to the profits generated. These results validate Hypotheses 1 and 2, which proposed that rising electricity prices and reduced financial support did not negatively impact companies' profitability.

Sunsol and Atum Energy achieved returns on investment of 36% and 41%, respectively, confirming the profitability of their operations. Further data analysis confirmed the achievement of Specific Objective 3, which aimed to evaluate the effectiveness of companies' investment strategies.

DOI: 10.34659/eis.2026.97.2.1139

Table 4. Factors and levels Organisational Readiness Measurement Metric

Organizational Readiness Measurement Metric			
Indicators	**Levels of organizational readiness**		
	Low level	**Moderate level**	**High level**
1. Sustainable development strategy	- lack of a sustainable development strategy;	- partial alignment with the sustainable development strategy;	- a sustainable development strategy is in place;
2. ESG integration	- absence of integration of ESG practices into the business model;	- implementation of selected ESG practices;	- ESG principles are integrated across all managerial functions;
3. Adaptive capacity	- limited adaptive capacity; - elevated operational risk;	- moderate responsiveness;	- well-developed dynamic capabilities are present, along with a culture of continuous learning;
4. Dynamic capabilities	- underdeveloped - inefficient resource utilization;	- partially developed;	- well-developed, culture of continuous learning;
5. Data and digital tools	- lack of data-driven systems;	- basic digital adoption;	- data-driven tools are actively utilized;
6. Risk and finance management	- high operational risk, limited access to capital (especially green finance);	- moderate access to funding, reliance on public subsidies;	- advanced use of AI, IoT, EMS and analytics tools; - stable financial structure, access to ESG funds and green bonds;
7. Green technology investment	- minimal or occasional; - restricted access to capital (particularly green financing);	- gradual technological upgrades; - investment in incremental technological upgrades;	- the firm proactively adapts to changes in the regulatory environment; - strategic investments are made in green technologies.
Results from the Organizational Readiness Measurement Metric at Various Levels			
1. Financial performance	- poor financial performance; - high costs, limited revenue sources;	- average financial and innovation performance;	- achieve superior financial performance (as a result of cost efficiency and revenue diversification);
2. Innovation output	- low level of innovation activity; - low R&D activity, little or no product development;	- incremental innovation, limited product differentiation;	- higher level of innovativeness (R&D activities, product diversification, digital transformation);
3. Market competitiveness	- marginal competitive position in the renewable energy market;	- lack of systemic integration of sustainable development into operational activities; - competitive advantage is not sustainable; - absence of a clear strategic response to regulatory and market changes.	- sustainable competitive advantage (based on brand strength, stakeholder trust, and first-mover benefits)
companies	Atum Energy, Sunsol	Solar Bruk Bet, Selfa photovoltaics	House Solutions

Source: author's work based on qualitative research.

DOI: 10.34659/eis.2026.97.2.1139

The three-level model of organisational readiness in photovoltaic enterprises is of critical importance from a strategic management perspective, as it enables the systematic differentiation of organisational maturity in relation to the challenges of sustainable development.

The first hypothesis assumed that the reduction in financial support, such as the "My Electricity" program, did not have a significant impact on the financial performance of photovoltaic companies. The second hypothesis suggested that the increase in electricity prices between 2019 and 2021 significantly improved the financial performance of the analysed enterprises. The third hypothesis assumed that companies that increased their investment in fixed assets and technological development achieved higher profitability. The fourth hypothesis suggested that despite rising operating costs, caused by increasing raw material prices and CO_2 emission costs, photovoltaic enterprises were able to maintain positive financial results. The fifth hypothesis was based on the assumption that companies with similar balance sheet totals achieved comparable profitability, meaning that external factors, such as subsidies and energy prices, had a similar impact on their financial results.

In summary, all hypotheses were confirmed by the collected data, and the study demonstrated that the photovoltaic sector in Poland exhibits high flexibility and resilience to changing market conditions, allowing companies to achieve profitability even in more challenging years.

In further research, the most important is the scientific justification for the significance of the Three-Level Model of Organisational Readiness. A classification framework for inter-organisational comparisons – the model enables the classification of enterprises according to their level of organisational maturity, which facilitates comparisons of strategic, technological, and cultural development stages. Such a typology enhances the validity of empirical analyses and supports the identification of gaps in organisational preparedness for the energy transition.

Conclusions

Organisational readiness constitutes a multidimensional construct encompassing the strategic, structural, operational, and cultural capacity of a firm to effectively respond to external stimuli – particularly those arising from sustainability imperatives. In the context of the photovoltaic (PV) sector, differentiated levels of organisational readiness significantly affect firms' ability to generate economic value, foster innovation, and maintain long-term competitiveness.

Modelling and simulation are employed to analyse the impacts of various scenarios on the performance of renewable energy systems. These analyses may include assessing the effects of climate change, fluctuations in energy demand, and integration with other energy sources. Such evaluations enable the development of adaptation and optimisation strategies to enhance system resilience and efficiency in response to these variations. The evolution of scientific output demonstrates an exponential increase in interest and research activity in the field of simulation and modelling for renewable energy.

An important achievement of this study is to indicate that changes in subsidy policy and energy price volatility affected the profitability of selected photovoltaic companies in Poland in 2019-2021. With changing energy prices and an unstable economic situation, the profitability of investments by companies in the photovoltaic industry in the analysed period depends on the subsidy system. The long-term potential of photovoltaic energy is vast, with projections indicating a continuous increase in its share of global electricity generation. As technological, economic, and policy factors align, solar energy is expected to play a leading role in the global transition toward a sustainable and carbon-neutral energy future. In sum, the level of organisational readiness in PV enterprises plays a determinative role in shaping their financial resilience, innovation dynamics, and market competitiveness. Future research should further investigate the causal mechanisms linking readiness dimensions with firm-level outcomes and explore sector-specific moderating variables such as regulatory volatility, technological intensity, and access to green capital.

Acknowledgements

The research was carried out as part of project no. WZ/WIZ-INZ/3/2026 at the Białystok University of Technology and financed from a research subsidy provided by the minister responsible for science.

DOI: 10.34659/eis.2026.97.2.1139

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DOI: 10.34659/eis.2026.97.2.1139

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STRATEGICZNE UWARUNKOWANIA GOTOWOŚCI ORGANIZACYJNEJ DO ZRÓWNOWAŻONEGO ROZWOJU W POLSKICH PRZEDSIĘBIORSTWACH FOTOWOLTAICZNYCH

STRESZCZENIE: Celem artykułu jest przedstawienie wyników badania dotyczącego gotowości organizacyjnej polskich przedsiębiorstw fotowoltaicznych (PV) do wdrażania zasad zrównoważonego rozwoju. W badaniu zastosowano triangulację metod badawczych, łącząc podejście ilościowe i jakościowe. Komponent ilościowy, przeprowadzony na próbie 50 przedsiębiorstw branży fotowoltaicznej, został uzupełniony analizą jakościową, ukierunkowaną na identyfikację czynników wpływających na aktualny stan oraz potencjał rozwojowy praktyk zrównoważonego rozwoju w poszczególnych firmach. Uzyskane wyniki pozwoliły na empiryczne odniesienie się do postawionych pytań badawczych oraz potwierdzenie sformułowanych hipotez. Badanie wypełniło istniejącą lukę badawczą dotyczącą braku zintegrowanych ram teoretycznych gotowości organizacyjnej w sektorze fotowoltaicznym, które uwzględniają technologiczne, operacyjne, finansowe i instytucjonalne aspekty w kontekście rozwoju odnawialnych źródeł energii. Ponadto, badanie wykazało związek pomiędzy poziomem gotowości organizacyjnej a wynikami przedsiębiorstw. Analiza empiryczna ukazała, w jaki sposób zróżnicowane poziomy gotowości wpływają na rezultaty finansowe, zdolność innowacyjną oraz pozycję konkurencyjną firm fotowoltaicznych. Ostatecznie opracowano metrykę pomiaru gotowości organizacyjnej, umożliwiającą ocenę stopnia przygotowania przedsiębiorstw do wdrażania strategii zorientowanych na zrównoważony rozwój w branży fotowoltaicznej.

SŁOWA KLUCZOWE: przedsiębiorstwo fotowoltaiczne, gotowość organizacyjna, zrównoważony rozwój, zarządzanie strategiczne, zrównoważoność środowiskowa

DOI: 10.34659/eis.2026.97.2.1139